

THE VERTICAL DISTRIBUTION OF POTATO CYST NEMATODES IN AIN DEFLA (ALGERIA)

NADIA TIRCHI¹, AISSA MOKABLI² & FAZIA MOUHOUCHE³

^{1,2}Faculty of Natural Sciences and Life, University Djilali Bounaama Khemis Miliana, Ain Defla, Algeria

³Department of Zoology and Agricultural Forestière, National School of Agronomy, El Harrach, Algeria

ABSTRACT

Among cyst nematodes species; *Globodera rostochiensis* and *Globodera pallida* are the most important pests for potato crop in the world. This devastating group took a large extension in the zones to potato vocation of Algeria. The vertical distribution of those parasitic-nematodes in soil is affected by environment factors. Investigating was conducted in three localities of Ain Defla region (Algeria) on the vertical distribution of those parasites during two development stages of potato plant. The results showed that in sprout stage, number of collected cysts in the different sites were significantly different. However; no significant differences were noted between studied soil depths of the same site. During the maturation stage, the number of collected cysts was significantly different in the prospected sites. In the same way, cyst number showed variability within the soil depth. This study shows that there is not direct relation between the pH and total limestone rate (%CaCo₃) of soil with the vertical distribution of the cysts of PCNs.

KEYWORDS: Potato Cyst Nematodes, Vertical Distribution, Site, Development Stage

INTRODUCTION

The Potato cyst nematodes (PCNs), *Globodera rostochiensis* (Wollenweber, 1923) and *Globodera pallida* (Stone, 1973), cause quantitative and qualitative losses in potato crops in several countries (PHILIS, 1991; GRECO *et al*, 1993; MARKS and BRODIE, 1998; VAN RIEL and MULDER, 1998, OEPP, 2004). These roots parasites persist in soil during several years in the state of encysted females. They are very dangerous seen the insidious beginning of their attacks, their highly elevated multiplication, the scattering and the longevity of the cysts in soil, their easy dissemination and the difficulty of their detection which makes difficult the intervention methods (SCHNEIDER and MEGGNIERY, 1971). They are considered like organisms of quarantine in several countries in the world (BÉLAIR, 2005, BÉLAIR, 2008; CHAUVIN *et al*, 2008, HODDA and COOK, 2009).

The distribution of the nematodes in soil is heterogeneous and influenced by several factors, mainly plant host (development stage, importance and shape of the roots and nature of their exudates), cultural practices (irrigation, tillage) and by other factors bound to the type of soil (texture, content in organic matter, pH, limestone rate) (ROUSSELLE *et al*, 1996; BEEN and SCHOMAKER, 2000).

The survey of the vertical distribution in soil of those two species of PCNs within the soil profile is most important to develop control strategies. The aim of this investigation was to obtain some informations on the vertical distribution of the cysts of PCNs *Globodera* sp. within the soil rhizosphere of potato plants in relation with two pH and rate of limestone.

MATERIALS AND METHODS

Study Sites

The vertical distribution of potato cyst nematode was conducted in field situated in three localities, Bourached, El Amra and Mekhatria located in Ain Defla region of Algeria which is situated to 140 Km of the Algiers capital (36° 15' 55'' N, 1° 58' 13'' E). This area is characterized by a semi-arid Mediterranean climate and 500 to 600 mm annual rainfall.

Sampling

Soil samples were collected from three plots (500 m² each) during two development stages of the potato culture. The first has been achieved in March 2013 during sprout stage and the second in May, corresponding to the maturation phase.

In each parcel 20 elementary samples of 100g were collected from the rhizosphere soil of potato plants from the depth of 0-15, 15-30 and 30-40 cm. Then, all elementary samples of each depth were mixed in a representative composite sample weighing 2kg. From each composite sample, five sub-samples weighing 300 g were appropriated to constitute repetitions for the nematological analysis. Cysts were extracted from each sub soil samples by using method described by FENUICK (1940). In the same way, of every composite soil sample considered, five sub-samples are kept to determine soil pH using pH meter and total limestone rate (%CaCo₃) with Bernard calcimeter according to the method described (DUCHAUFOR, 1977), in order to evaluate their impact on the vertical distribution of PCNs populations.

Statistical Analysis Methods

Statistical analysis was performed using the STATISTICA program (version 6.1). All data were analyzed by ANOVA. Also, to determine the relationships between soil pH and o total limestone rate with vertical distribution of cysts of PCNs, principal component analysis was conducted.

RESULTS

The number of mature cysts is different between the three surveyed sites in the two development stage of potato (Table1).

Table 1: The Cyst Number with Soil Profile in Prospected Sites

Stations	Number of Cyst in Sprout Stage			Number of Cyst in Maturation Stage		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
El Amra	41,2±13,48	34,8±7,49	46±13,87	35,8±4,66	21,4±10,29	20,8±4,32
Bourached	3,6±3,7	8,2±3,56	6,2±2,17	7,6±1,82	11,4±2,30	8±1,58
Mekhatria	24,4±6,35	29,4±14,79	17,8±2,86	19,2±6,94	9,4±1,52	22,4±4,77

Cysts Distribution in Sprout Stage

During the sprout stage, in the three studied sites, the number of collected cysts was not significantly different between the three depths (p=0.88), However, the number of cyst collected in the different sites is very significantly different (P<0.0005). No significant differences were noted for the interaction of factors site and depth (Figure 1; Table 2)

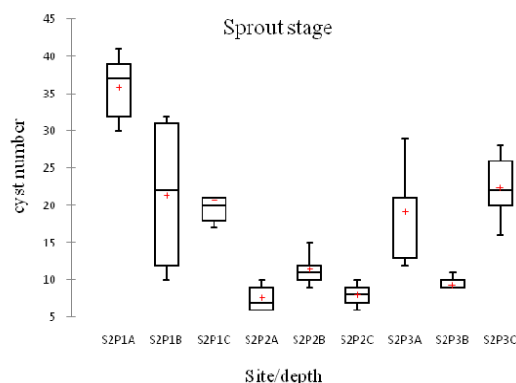


Figure 1: Variability of Number of Cysts between the Three Depths in Studied Sites during Sprout Stage

S1: stage 1 (Sprout stage), **P1:** site 1 (El Amra), **P2:** site 2 (Bourached), **P3:** site 3 (Mekhatia)

A: depth of 0-15 cm, **B:** depth of 15-30 cm, **C:** depth of 30-45 cm.

Table 2: Analysis of Variance of the Number of Cysts According to the Studied Sites and the Depth in the Sprout Stage

	Effect	SC	DDL	F	P
ord. origine	23679,19	1	23679,19	286,2687	0,000000
site	8870,67	2	4435,33	53,6208	0,000000
depth	21,08	2	10,54	0,1274	0,880695
site*depth	840,68	4	210,17	2,5408	0,054151
Erreur	3391,38	41	82,72		

Cysts Distribution in Maturation Stage

During maturation, a variability of the vertical distribution of cysts was noted in prospected areas. In the first site, number of cyst collected in superficial soil layer (0-15cm) was the higher in comparison than those found in 15-30 and 30-45 cm soil depth. In the second site, the higher number of cyst was found in 15-30 cm soil depth in comparison to 0-15 cm and 30-45 cm soil depth. Different distribution is found in the third site where the highest amount of cysts of those nematodes was located in the higher soil depth 30-45cm, the difference was very significant in comparison with the numbers of cysts collected in the soil depth of 0-15 cm and 15- 30 cm. The results of ANOVA (Fi.g.2; Table3) revealed very highly significant differences for factor site and

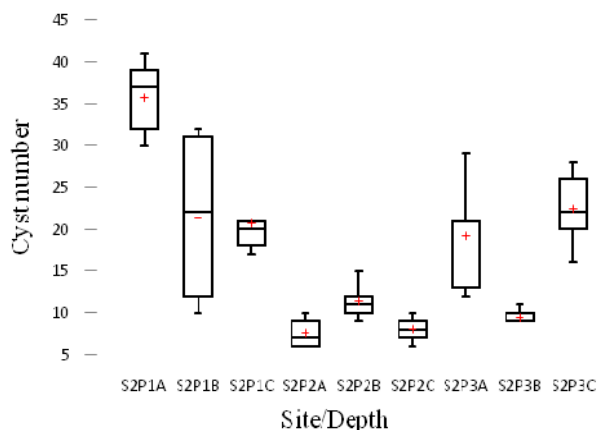


Figure 2: Variability of Cyst Number between the Three Depths in the Three Parcels During Maturation Stage

S2: stage 2 (maturation), **P1:** site 1 (El Amra), **P2:** site 2 (Bourached), **P3:** site 3 (Mekhatria)

A: depth of 0-15 cm, **B:** depth of 15-30 cm, **C:** depth of 30-45 cm.

Table 3: Analysis of Variance of the Number of Cysts According to the Studied Sites and the Depth in the Maturation Stage

	Effect	SC	DDL	F	P
ord. origine	13520,00	1	13520,00	527,6670	0,000000
site	2170,00	2	1085,00	42,3461	0,000000
depth	348,40	2	174,20	6,7988	0,003127
site*depth	875,20	4	218,80	8,5395	0,000059
Erreur	922,40	36	25,62		

Effect of pH and Total Limestone Rate % CaCo₃ on Vertical Distribution of Cysts of Potato Cyst Nematodes

The analysis of the relative results to the soil pH in the different depths during the two development stages of the potato culture revealed significant differences between the values unregistered in sprout stage and those obtained in maturation stage ($p < 0.0005$). In the same way, very highly significant differences were recorded for pH values in the studied investigated sites. However, no significant differences were recorded of pH values of the different soil depths of the same site ($p = 0.23$) (Table 4; Figure 3, 4, 5).

Table 4: Ph Values within Soil Profile in Studied Sites

Station	Ph Values During Sprout Stage			Ph Values During Maturation Stage		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
El Amra	6,83±0.18	6,9±0.31	6,59±0.19	8,3±0.03	8,4±0.03	8,35±0.02
Bourached	6,69±0.05	6,11±0.84	6,62±0.11	8,26±0.01	8,26±0.02	8,22±0.02
Mekhatria	6,59±0.24	6,99±0.44	6,61±0.4	8,44±0.04	8,38±0.02	8,37±0.06

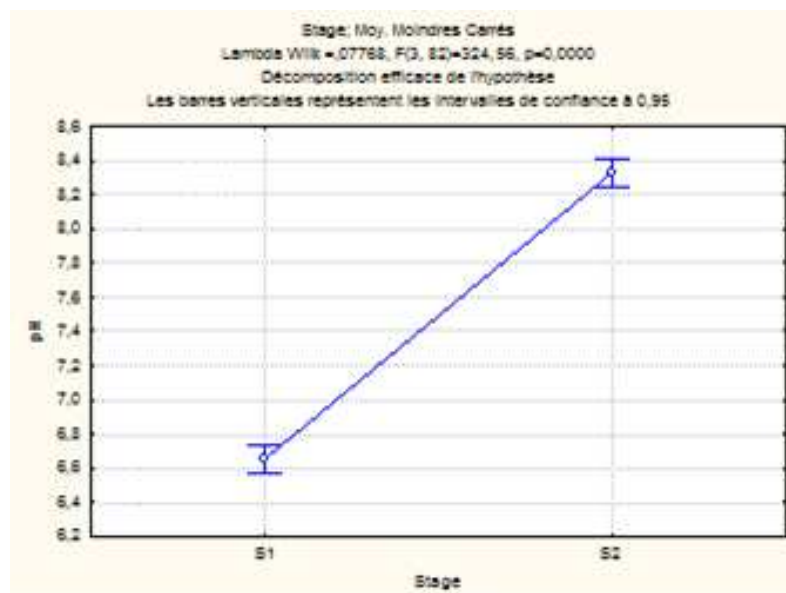


Figure 3: Variation of pH between Sprout Stage (S1) and Maturation Stage (S2)

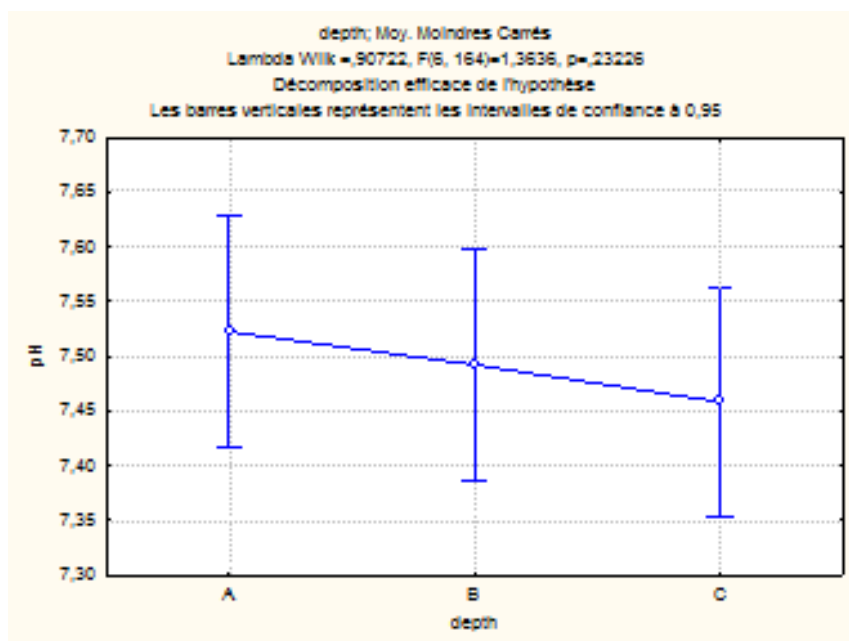


Figure 4: Variation of pH within Soil Depths

A: depth of 0-15 cm, B: depth of 15-30 cm, C: depth of 30-45 cm

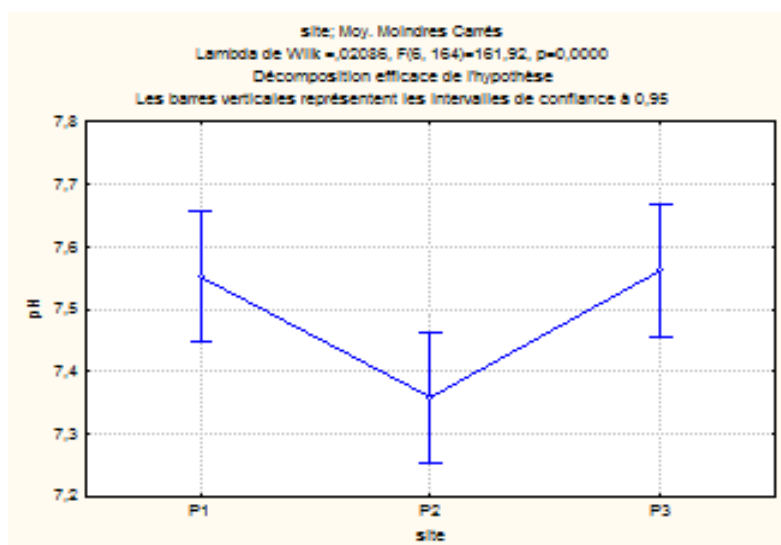


Figure 5: Variation of pH in the studied Sites

P1: site 1 (El Amra), P2: site 2 (Bourached), P3: site 3 (Mekhatria)

Concerning total limestone rate % CaCo_3 , very highly significant differences were noted between sprout stage and maturation stage ($p < 0.0005$). The differences were also, very highly significant for variable site ($p < 0.0005$). In the same way, significant differences for % CaCo_3 values were noted between the different soil depths ($p = 0.017$) (Table 5; Figure 6, 7, 8).

Table 5: Total Limestone Rate (%CaCo3) with Soil Profile in Studied Sites

Station	(%CaCo3) Values during Sprout Stage			(%CaCo3) Values during Maturation Stage		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
El Amra	9.99±0.4	9.8±0.4	9.52±0.21	8.4±0.22	8.4±0.19	9.86±0.13
Bourached	9.32±0.4	9.33±0.52	9.71±0.26	7.15±0.42	7.15±0.74	7.11±0.34
Mekhatria	4.05±0.26	3.77±0.74	5.09±0.39	3.47±0.32	3.9±0.18	3.94±0.32

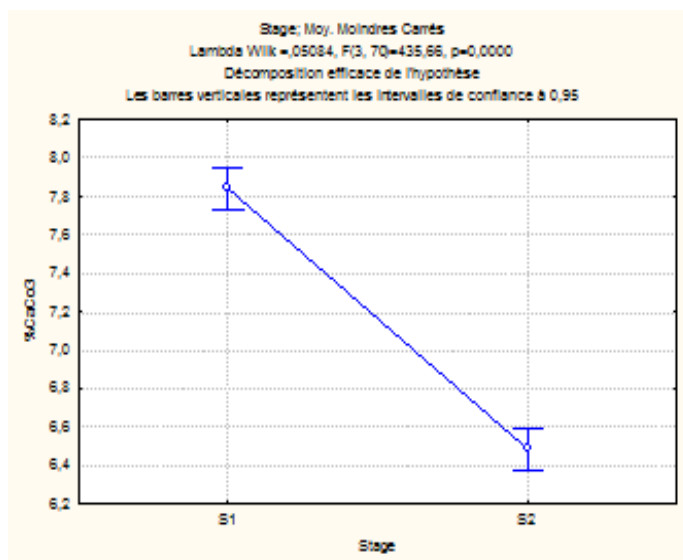


Figure 6: Variation of %Caco3 between Sprout Stage (S1) and Maturation Stage (S2)

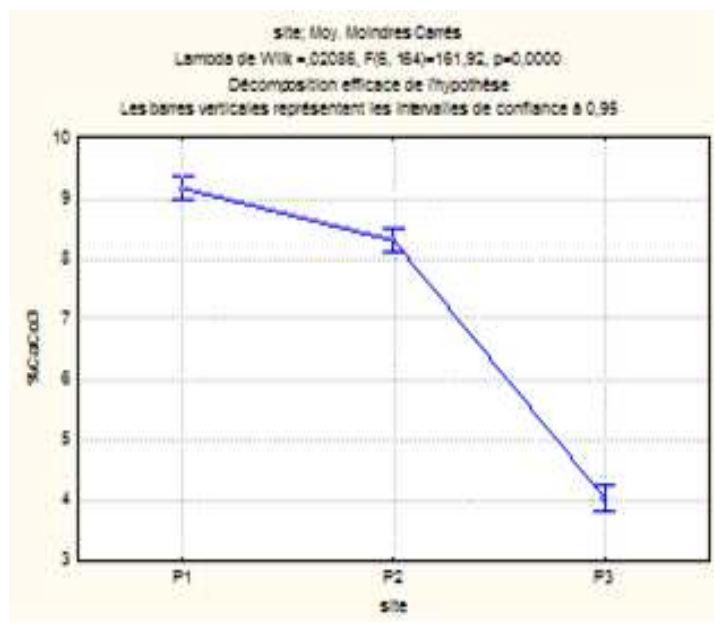


Figure 7: Variation of Ph in the Studied Sites

P1: site 1 (El Amra), **P2:** site 2 (Bourached), **P3:** site 3 (Mekhatria)

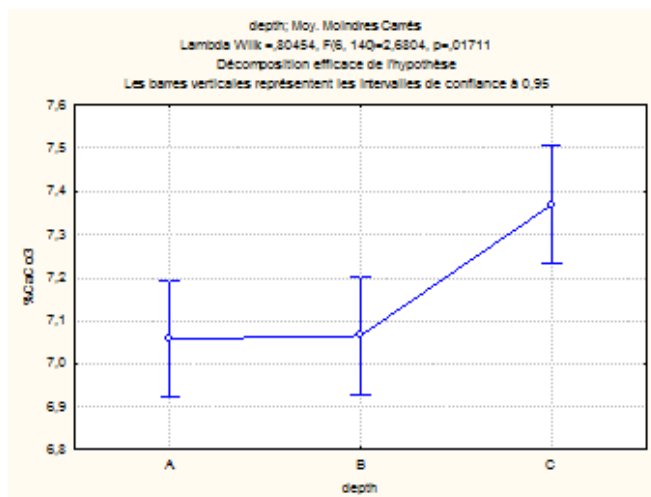


Figure 8: Variation of %CaCo3 within Soil Depths

A: depth of 0-15 cm, **B:** depth of 15-30 cm, **C:** depth of 30-45 cm

Principal Component Analysis (PCA)

The analysis of variables distribution in the correlation circle (Figure 9), show that the vertical distribution of potato cyst nematodes is independent of total limestone rate and pH of soil. However, the number of these parasites is related to the survey site and the host plant stage

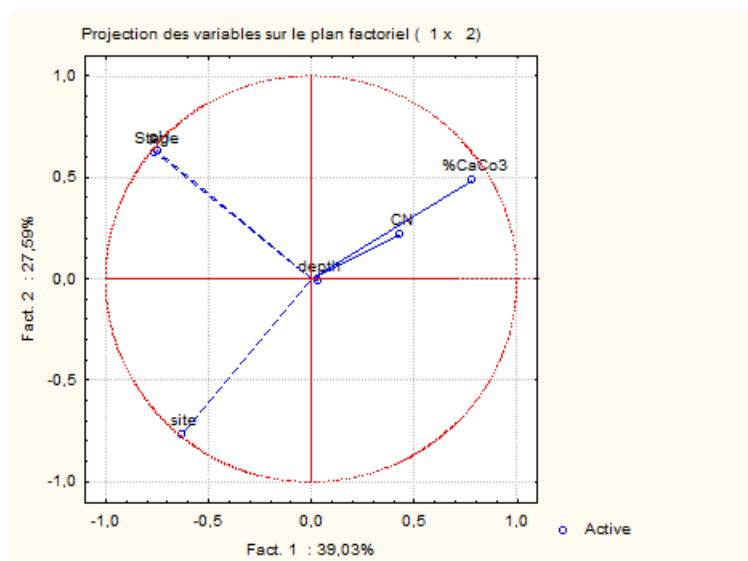


Figure 9: Principal Component Analysis between the Vertical of Distribution of Potato Cyst Nematode and Variables Considered

DISCUSSIONS AND CONCLUSIONS

The data analysis revealed a variability of the vertical distribution of potato cyst nematodes within the same site between the two development stages of potato plant. In sprout stage, there was homogeneous distribution of cysts within soil depths in all studied sites. This could be due to the deep tillage preceding the sowing which can mix the soil of the different depths. HOU *et al.* (2010) reported that nematodes showed variable responses to different tillage practices. BEEN

and SCHOMAKER (2000) reported that the spatial distribution of cysts within the soil profile is partially affected by agricultural practices, mainly by tillage.

During the maturation stage, differences in the vertical distribution were noted between the studied sites. In the first parcel of El Amra the number of cysts decreases with soil depth. However, we collected a highest number of cysts in 15-30 cm in the second site (Bourached) and in 30-40 cm soil depth in the third sites (Mekhatria) in comparison with superficial depth. This could be due to the transport of mature cysts from upper to deeper soil layers (RENČO *et al*, 2011). This could be partially related to the plant roots growth. The factors that influence nematode distribution most are the host roots presence, rooting patterns and root exudates (SCHNEIDER et MUGNIERY, 1971; VALDEZ, 1974; ROUSSELLE *et al*, 1996). The potato cyst nematodes (PCNs) *Globodera rostochiensis* and *G. pallida*, were found in high numbers in soil depth of 20-40 cm as in soil depth 0-20 cm (WHITEHEAD, 1977).

The study of nematode vertical distribution in the soil profile is difficult due to many interrelated factors including moisture, temperature and soil texture. However, the factors that influence significantly nematode distribution are the host roots presence, rooting patterns and root (VALDEZ, 1974; WHITEHEAD and TURNER, 1998). Further survey of different soil profile layers in potato fields should be conducted to complete the information on the vertical distribution of PCNs. All the factors which can affect their distribution must be taking in consideration.

The occupation and strategic extension of nematodes species *Globodera rostochiensis* and *Globodera pallida* occur in relationship with the potato cultivation. Management of rotation is set up to reduce the extension those pests in futur years.

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